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In memoriam Israel Gohberg (1928–2009)[☆]

Israel Gohberg was born on August 23, 1928, at Tarutino (in Bessarabia, then part of Romania), and died on October 12, 2009, at Ra'anana (Israel). In the 81 years of his life he had to surmount great difficulties. By the vagaries of circumstance he passed a major part of his life in the Soviet Union. There he was continually subject to discrimination, which he managed to overcome in an astounding manner. He succeeded in making Kishinev, in the Soviet Republic Moldavia, an important center of functional analysis. In 1974 he immigrated to Israel, where he became a professor at the University of Tel Aviv. Gohberg developed into an international authority in the area of operator theory and singular integral equations. He inspired research groups at a number of universities, among them the VU University in Amsterdam.

The years prior to 1974. Israel Tsudikovich Gohberg was born in Bessarabia, a region with a substantial Jewish minority. Bessarabia has had a turbulent history. Long under Turkish domination, it became part of tsarist Russia in the 19th century, but in 1918 came under the jurisdiction of Romania. As a side-effect of the non-agression pact between Germany and the Soviet Union of 1939, Bessarabia in 1940 became part of the Soviet Republic Moldavia. A few months later, on Israel's 12th birthday, his father Tsudik was arrested and deported to the Gulag. In his small printshop Tsudik had employed a few people, and afterwards it turned out that he had been accused of capitalistic exploitation and zionism. A year and a half later he perished in the Gulag, but his wife Clara and the children Izja and Fanja remained unaware of his fate for years. When Germany invaded the Soviet Union and Romania invaded Moldavia in 1941, they had to flee. After extended wandering they wound up in the Soviet Republic Kirgizia, in a small village close to the capital Frunze. Here mother Clara found a meager livelihood as a maternity nurse. Izja went to high school, where he found a stimulating mathematics teacher who had recently arrived from Warsaw. In 1946, Israel went to the State Pedagogical Institute in Frunze, where he soon obtained a Stalin stipend. Mother Clara had hoped that he would become a medical doctor, but encouraged by his teachers, Israel decided on mathematics. For his study he went all the way back to Moldavia, in 1948. A few years later his mother and sister would follow him.

At the University of Kishinev (Chisinau), in Moldavia, he found young mathematics teachers from good universities. They introduced him to modern topics, among them integral equations and operator theory, the subjects that would play the major role in his subsequent research. His early results on Fredholm operators and index drew the attention of S.M. Nikolsky and

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A.N. Kolmogorov in Moscow, and they were published in a good journal, 'Doklady'. In 1950, Gohberg took the initiative to visit the versatile Jewish mathematician Marc G. Krein in Odessa. Krein was, among other things, an expert in, among other things, the area of operator theory. Not long before he had been dismissed from the University of Odessa, but he had found a position as professor of mechanics at the Naval Engineering Institute. Gohberg would have liked to start working under Krein, but the Institute was not allowed to accept Jewish students. Nevertheless the visit marked the beginning of intensive collaboration with Krein, which would result in important publications. We mention the large article of 1958 on systems of Wiener–Hopf integral equations, and the factorization theorems of matrix functions. Later there would be epoch making books on operator theory.

As an aside, observe that a Wiener–Hopf equation

$$f(x) - \int_0^\infty K(x-y)f(y)dy = g(x) \quad (-\infty < x < \infty)$$

is much more difficult than a convolution equation for f, in which the integration extends from $-\infty$ to ∞.

In the meantime Gohberg had, in 1951, obtained a master's degree at Kishinev. After that he had to start working at a teacher training school in Soroki, in the northern part of Moldavia. These last years of Stalin's life were difficult and very dangerous for Jewish citizens, who could be arrested upon the slightest pretext. In 1953, Gohberg could move along with the director of his school, a mathematician, who became director of the Pedagogical Institute at Beltsy, a larger city in Moldavia. Alongside his teaching, Gohberg could now work on a dissertation, supported from afar by Krein. The thesis was completed in Leningrad, early in 1954. There he met many well-known mathematicians and learned a great deal. He got a better position at Beltsy and finally became head of the mathematics department. Thanks to his improved circumstances he could help his mother and sister to return from Frunze to Moldavia. His sister had started a study of medicine and would later become a surgeon.

It was important for Gohberg that in 1956, he could actively participate in a conference on functional analysis in Moscow, organized by I.M. Gelfand and S.V. Fomin. This was the time when Gelfand and coauthors wrote their influential series of books on generalized functions ('distributions') and their applications. After the conference, Gohberg got married to Bella Jakovlevna, a friend of Israel's sister. Bella had almost completed her study of medicine, and has faithfully supported Israel all his life, later also as a physician. Where it had been his mother's ambition to have a medical doctor in the family, there finally were two!

In 1959, Gohberg gave up his position at Beltsy (and a higher salary) for a research position in Kishinev. This was at a society that would soon become the Moldavian Academy of Science. There he would become the head of a new section, Functional Analysis. At this time the collaboration with Krein in Odessa was intensified. Among other things it was planned to write a comprehensive work on operator theory. That project took many years, in part because Krein imposed very high standards both as to contents and exposition. He always insisted on the inclusion of the most recent results, even if at the time no complete proofs had been published. For that reason much material had to be rewritten several times, while providing full proofs was very time=consuming. Israel enjoyed telling the following anecdote about the progress of the work. At one time an acquaintance asked: 'How is the book going?' 'As a matter of fact', Israel would say, 'it is 85% complete.' 'But why then are you looking so gloomy?' 'Well, yesterday it was 95% complete.' The project finally resulted in two volumes, the authoritative books of Gohberg and Krein on Nonselfadjoint Operators and Volterra Operators. They appeared in 1965

and 1967, soon afterwards also in English translation. As one of the invited speakers at the large four-yearly International Congress of Mathematicians, which took place in Moscow in 1966, Krein gave an extensive report on the joint work.

In the meantime, Gohberg had completed his second dissertation, for the 'big' doctorate. After initial objections against 'yet another Jewish candidate', Moscow University admitted him to the defense (1964).

In the subsequent ten years, Gohberg made remote Kishinev an important center for analysis, in particular operator theory and its applications. Here he developed his factorization theorems for operator functions, which turned out to be important for astrophysics. The theory was worked out further with his pupil J. Leiterer from the DDR. With I.A. Feldman he developed a method for numerical solutions. Together with N.Ja. Krupnik he worked on singular integral operators. In these years it became an obstacle that Moscow strongly objected to the appointment of Jewish Ph.D. students. Also, attendance at meetings abroad (even in Eastern Europe), indispensable for contacts with the West, became very difficult. Recognition in the form of membership in a State Academy of Science was next to impossible.

The State Academies of Science played a special role in the Russian scientific world. Academy members enjoyed special privileges, including financially. At the top there was the prestigious central Academy in Moscow, which had to approve all appointments. From 1968 until 1984 not a single Jewish mathematician was a full member of the central Academy; it took until 1984 before the eminent mathematician I.M. Gelfand was elected. About the Ukrainian Academy it was jokingly said that it must be the best in the whole world, because M.G. Krein was only a corresponding member! After some wrangling, Gohberg became a corresponding member of the Moldavian Academy in 1970, but a recommendation for ordinary membership was stopped in Moscow.

Emigration. It was not surprising that around 1970, Gohberg began to think seriously about immigration to Israel. He had relatives there, among others at a kibbutz. After a difficult year as a 'refusenik' in the Soviet Union, Gohberg managed to emigrate in 1974. He was appointed professor at the University of Tel Aviv, where he soon received a special chair of analysis and operator theory.

The years after 1974. After the anxious and restrictive years in the Soviet Union, Gohberg could spread his wings. He developed an extensive international network of prominent collaborators and coauthors. He quickly became a regular visitor to, among other places, the Weizmann Institute in Israel, the University of Maryland at College Park, the University of New York at Stony Brook, and the VU University in Amsterdam. At the last university he held a regular position as a part-time professor from 1983 until 1998. Here he started a very successful collaboration with M.A. Kaashoek, which developed into an internationally known group in operator theory. This period in Gohberg's life is also marked by intensive contacts with engineers, notably working in electrical engineering and control theory. For many years he was a member of the steering committee that led the two-year international workshops on Mathematical Theory of Networks and Systems (MTNS). The contacts with engineers also inspired Gohberg's interest in 'computational aspects'. During the later part of his life this led to important publications in the area of numerical analysis and numerical linear algebra. The well-known Gohberg–Semencul formula for the inversion of a Toeplitz matrix of 1972 had in the meantime found a place in the wider context of structured matrices.

Gohberg's mathematical work from the years after 1974 is very extensive. Two major themes came to the fore. The first concerns a systematic analysis of matrix and operator polynomials,

rational matrix functions and analytic operator functions in terms of associated spectral data such as zeros and poles. This theme was on the one hand inspired by the spectral analysis of nonselfajoint operators, especially the theory of characteristic operator functions, and was on the other hand characterized by systematic use of techniques from mathematical systems theory, such as those developed by Kalman in the 1960's. This symbiosis led to a large number of publications, and soon thereafter to three books, of which the first, 'Minimal factorization of matrix and operator functions' appeared in 1979, with H. Bart and M.A. Kaashoek as coauthors. This book marked a new relation between linear algebra and operator theory, and was the beginning of important applications to, among other areas, inverse problems for canonical differential equations and inversion problems for convolution equations such as appear in mathematical physics. In subsequent years these and other applications were systematically developed by Gohberg and various coauthors.

The second main theme concerns problems of interpolation, extension and completion. In the case of operators the problem involves a reconstruction on the basis of incomplete data. Jointly with H. Dym, M.A. Kaashoek and H.J. Woerdeman, Gohberg developed the so-called band method. With that tool, classical interpolation problems of Nevanlinna and Pick, of Schur and of Carathéodory from the beginning of the 20th century could be considered in a new context. It was then possible to treat and solve these, and more recent matrix and operator valued versions of the problems, by a common method. The same method could be applied to the two-block and four-block problems from systems and control theory. It was also effective for non-stationary extension problems involving different classes of finite and infinite matrices. The two themes come together in the book 'Interpolation of rational matrix functions' (1990) by J.A. Ball, Gohberg and L. Rodman. Part 5 of this book is devoted entirely to applications in control theory.

In the years after 1974, Gohberg also returned to early joint work with his pupils N.Ya. Krupnik and J. Leiterer in Kishinev. At the beginning of the 1990's he and Krupnik, by then a professor at Bar Ilan University in Israel, wrote two books on one-dimensional singular linear integral equations. Recently he and Leiterer, now a professor in Berlin, published a book 'Holomorphic operator functions of a single variable. Local/global theory'.

More on Gohberg's scientific work. Gohberg is undisputed leader in the area of nonselfajoint operators, spectral theory and factorization of matrix and operator functions, and inverse problems for structured matrices. His work is used also outside mathematics, in particular by astrophysicists and engineers. Alone or together with others he supervised more than 40 Ph.D. students, and he organized numerous international meetings. He was author or coauthor of more than 450 publications, among them 25 books. Exceptionally large numbers for a mathematician!

Apart from two small books on geometric subjects with Boltjansky, Gohberg's publications all belong to the area of analysis, operator theory and linear algebra. The two books with Marc Krein on operator theory mentioned earlier have become world famous. Other successful books are his 'Basic operator theory', together with S. Goldberg, and 'Classes of linear operators I and II', together with S. Goldberg and M.A. Kaashoek. We also mention the books 'Matrix polynomials' and 'Indefinite linear algebra and applications', both with P. Lancaster and L. Rodman. In this obituary it is impossible to do justice to all the books, let alone the articles. The reader may get a good impression of Gohberg's extensive works by consulting the commemorative volume which appeared on the occasion of his 80th birthday, 'Israel Gohberg and friends', edited by H. Bart, T. Hempfling and M.A. Kaashoek, and published by Birkhäuser Verlag, Basel, 2008.

Gohberg was founder and final editor of the influential journal 'Integral Equations and Operator Theory', published by Birkhäuser, and furthermore was founder and final editor of

the series of monographs 'Operator Theory: Advances and Applications', likewise published by Birkhäuser (more than 190 volumes).

Gohberg received many honors. He became an honorary doctor at the Technical University at Darmstadt, the Technical University in Vienna, the University of Timisoara in Romania, the Universities of Chisinau and Balti in Moldavia, and the Technion at Haifa. The Royal Netherlands Academy of Arts and Sciences elected him to foreign membership in 1985. In Israel he obtained the Landau Prize and the Rothschild Prize for Mathematics, in Germany the Humboldt Research Prize, in the US the Hans Schneider Prize in Linear Algebra, and in the Ukraine the M.G. Krein Prize. In 2009 he was elected Fellow of the international Society for Industrial and Applied Mathematics (SIAM).

For mathematics in the Netherlands, Gohberg has been of great importance. Operator theory was a relatively minor subject in this country, but his arrival made it flourish: notably at the VU University, but leaving no university untouched. We will remember him as an eminent mathematician, with tremendous energy, enormous enthusiasm, irresistible charm and a very special sense of humor.

For me personally he became an unforgettable friend, who showed me around in his new country of Israel with great pride.

The author thanks his friend and colleague Rien Kaashoek of the VU University for detailed information on Gohberg's scientific work.

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